



**UNIVERSITI PUTRA MALAYSIA**

**DESIGN AND SIMULATION OF DIFFERENTIAL P.ROTECTIVE  
RELAY (DPR) TO 33/11kV DELTA-WYE TRANSFORMER USING  
SABER SOFTWARE SIMULATOR**

**MUHAMMAD MURTADHA BIN OTHMAN**

**FK 2000 25**

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**MASTER OF SCIENCE  
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**2000**



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SOFTWARE SIMULATOR**

**BY**

**MUHAMMAD MURTADHA BIN OTHMAN**

**Thesis Submitted in Fulfilment of the Requirements for the  
Degree of Master of Science in the Faculty of Science  
Universiti Putra Malaysia**

**September 2000**



## DEDICATION

*To my beloved mother Jamilah Bte Abd. Basit,*

*my father Othman Bin Nor*

*&*

*to all my brothers and sisters.*

*May Allah bless all of you.*

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in  
fulfilment of the requirements for the degree of Master of Science

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(DPR) TO 33/11kV DELTA-WYE TRANSFORMER USING SABER  
SOFTWARE SIMULATOR**

**By**

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**September 2000**

**Chairman: Norman Mariun, Ph.D.**

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Substation automation constitutes the integral part of distribution automation. An automated distribution system may require many remote and central intelligent controllers or computers running synchronously in a very large boundary that are capable of making decisions and performing control actions. A protective relay is a device that responds to abnormal conditions in an electrical power system to operate a circuit breaker to disconnect the faulty section of the system with the minimum interruption of supply. Reliability, speed and selectivity are the most desirable characteristics of a protective relay. Numerical relays play an essential role in various distribution automation functions, and instead of mere protection relays it is also able to interact with the other

instruments. In most utilities, power transformers often represent the expensive and also the largest capital purchase in the transmission and distribution system. The gas relay or bucholz relays is particularly important since it gives early warning of a slowly developing fault, permitting shutdown and repair before serious damage can occur. For short-circuit condition or internal faults, differential protective relays (DPR) are usually employed. In this project, SABER software simulator was used to implement solid-state digital-type components for the DPR. The project focused on the protection of 33/11kv delta-wye transformer when internal fault happens. 3 packages solid-state digital-type DPR were designed to protect delta-wye transformer when internal fault happens. There are several problems encountered in this project where in SABER, 1) it is difficult to configure an initial values for delta-wye transformer due to obtain a desired outputs on wye-side, 2) 3-phase generator cannot do any partial changes either leading or lagging power factor, and 3) during circuit breakers switching, very high surges appear which can cause destruction to the power system components. Hence to reduce surges below the allowable maximum value during switching, this can be solve by implementing circuit breakers that not only works as a switch but also as impedance. Circuit breakers impedance can also be assume as an arc extinguisher. By extinguish the arc, the surges also will be reduce. Hence the results of this project are not only to isolate the delta-wye transformer from the generator and as well loads when fault happened, but is also capable to reduce surges during circuit breakers switching.

Abstrak tesis yang dikemukakan Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

**REKAAN DAN SIMULASI GEGANTI PELINDUNG PEMBEZA (DPR)  
TERHADAP 33/11kV TRANSFORMASI DELTA –WAI  
MENGUNAKAN PERISIAN KOMPUTER  
SABER**

**Oleh**

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Keperluan stesen-pencawang automasi terkandung dalam bahagian automasi pengagihan. Automasi pengagihan juga memerlukan banyak kawalan jarak jauh dan juga pusat kawalan pintar atau komputer agar bahagian-bahagian sempadan yang luas dapat beroperasi secara selaras, berupaya untuk membuat keputusan sendiri dan juga kawalan. Fungsi geganti pelindung adalah untuk mengesan keadaan yang tidak stabil dalam sistem kuasa elektrik, dan juga berupaya memisahkan bahagian sistem yang rosak dengan mengawal operasi suis pemisah-litar, tanpa mengganggu penjanaan elektrik secara maksima. Boleh dipercayai, kelajuan dan pemilihan adalah ciri-ciri yang diperlukan oleh geganti pelindung. Geganti numerikal memainkan peranan yang penting dalam beberapa fungsi automasi pengagihan. Geganti numerikal juga berupaya berhubung dengan peralatan-peralatan yang lain Transformasi merupakan suatu alat yang mahal dan juga

merupakan jumlah pembelian yang terbanyak dalam sistem transmisi dan pengagihan. Ganti jenis gas atau ganti buchholz juga merupakan satu alat yang penting sebagai penunjuk amaran bahawa kerosakan mula berlaku. Seurus itu tindakan memberhentikan operasi dilakukan untuk melaksanakan kerja baikpulih sebelum kerosakan yang lebih teruk berlaku. Untuk litar-pintas dan kerosakan dalaman transformasi, ganti pelindung pembeza atau DPR selalunya digunakan. Dalam projek ini, program komputer jenis SABER digunakan untuk merekabentuk DPR menggunakan komponen digital. Fokus dalam projek ini adalah untuk melindungi 33/11kV transformasi delta-wai apabila berlakunya kerosakan dalaman atau litar-pintas. Tiga pakej digital DPR telah direka untuk melindungi transformasi delta-wai apabila kerosakan dalaman berlaku. Terdapat beberapa masalah dihadapi dalam projek ini dimana dalam penggunaan SABER, 1) adalah sukar untuk menetapkan nilai dalaman yang tepat untuk transformasi delta-wai, agar voltan keluaran bahagian wai diperolehi juga adalah tepat, 2) penjanaan elektrik jenis 3-fasa tidak boleh melakukan perubahan terhadap faktor kuasa atau p.f., dan 3) apabila suis pemisah-litar beroperasi, renjatan elektrik akan berlaku dan menyebabkan kerosakan pada komponen-komponen sistem kuasa elektrik. Untuk mengurangkan renjatan elektrik daripada nilai maksima yang dibenarkan, maka suis pemisah-litar bukan sahaja beroperasi sebagai suis tetapi juga sebagai perintang. Perintang yang terdapat pada suis pemisah-litar diandaikan sebagai penyah-ark, agar renjatan elektrik dapat dikurangkan. Jadi hasil yang diperolehi dalam projek ini, bukan saja untuk melindungi transformasi delta-wai apabila kerosakan atau litar-pintas berlaku, tetapi berupaya mengurangkan renjatan elektrik semasa suis pemisah-litar beroperasi.



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Wassalam

I certify that an Examination Committee met on 22 September 2000 to conduct the final examination of Muhammad Murtadha B. Othman, on his Master of Science thesis entitled "Design and Simulation of Differential Protective Relay (DPR) to 33/11kV Delta-Wye Transformer Using SABER Software Simulator" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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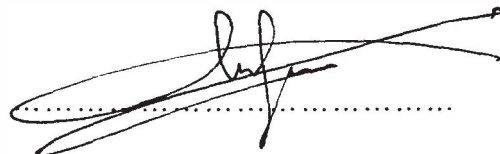


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## DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

A handwritten signature in black ink, consisting of a large, stylized 'M' followed by 'urtadha B. Othman'. The signature is written over a horizontal dotted line.

(Muhammad Murtadha B. Othman)

Date: 20/10/2000

## TABLE OF CONTENTS

ITEM	PAGE
DEDICATION	i
ABSTRACT	ii
ABSTRAK	iv
ACKNOWLEDGEMENTS	vi
APPROVAL SHEETS	vii
DECLARATION FORM	ix
LIST OF FIGURES	xiii
LIST OF TABLES	xviii
<b>CHAPTER</b>	
<b>1 INTRODUCTION</b>	<b>1</b>
1.1 Aim and Objectives	6
1.2 Scope of the Work	8
1.3 The Saber Simulator	10
<b>2 LITERATURE REVIEW</b>	<b>12</b>
2.1 Transformer Protection	15
2.2 Power Transformers	18
2.3 Dryformer	19
2.4 Differential Protection	20
2.5 Biased Differential Protection	24
2.6 High-Speed Biased System	26
2.7 Static Relays	29
2.7.1 RADSB Transformer Differential Relay	30
2.7.2 RALDA Differential Relay	32
2.7.3 Numerical Relays	35
2.7.4 Remote Terminal Units (RTUs)	37

2.8	Relay Design and Construction	39
2.9	Factors Affecting Design and Construction	40
2.10	Current Differential Relays	40
2.11	Comparison of Constants	43
2.12	Summary	49
<b>3</b>	<b>METHODOLOGY AND DESIGN</b>	<b>50</b>
3.1	Differential Relaying for Transformer Protection	50
3.1.1	RADSB Transformer Differential Relay	51
3.1.2	Block Diagrams of DPR with the Power System	53
3.1.3	General Guidelines for Transformer Differential Relay Applications	54
3.1.4	Sample Checks for Applying Transformer Differential Relays	57
3.1.5	Phasing Check	58
3.1.6	Relay Ratings Commonly Used for Type CA-26 and RADSB Relays	59
3.2	Circuits and Calculations	60
3.2.1	Delta-Wye Transformer	62
3.2.2	Application of Current Transformers and Differential Winding	70
3.2.3	Determination of Operating Windings and Restraining Windings for DPR	82
3.2.4	Amplitude and Phase Comparator	89
3.2.5	Amplitude Comparator	90
3.2.6	Phase Comparator	93
3.2.7	RADSB Transformer Differential Relay	95
3.3	Solid-State Digital-Type DPR	96
3.4	Circuit Breaker Tripping Circuit	97
3.5	Circuit Breaker	99
3.5.1	Circuit Breaker Tripping	101

<b>4</b>	<b>RESULTS AND DISCUSSION</b>	<b>110</b>
4.1	Results of an “Application of Differential Protective Relay (DPR) to 33/11kV Delta-wye Transformer for Substation Automation” by Using SABER	110
4.2	Discussion	126
4.3	Summary	129
<b>5</b>	<b>CONCLUSION AND SUGGESTIONS</b>	<b>130</b>
5.1	Conclusion	130
5.2	Suggestion for the Future Work	133
	<b>REFERENCES</b>	<b>134</b>
	<b>APPENDIX</b>	<b>137</b>
	A: Procedure to Run SABER	138
	B. Current Transformers	146
	<b>BIODATA OF AUTHORS</b>	<b>151</b>

## LIST OF FIGURES

FIGURE		PAGE
Figure 1	Scope of the Work	8
Figure 2.1	a, b and c. Merz-Price protection	14
Figure 2.2	Delta/Star Transformer. Current distribution under phase fault conditions	24
Figure 2.3	Biased differential protection	26
Figure 2.4	Biased differential relay: setting 40%. Bias slope 20%	26
Figure 2.5	Basic circuit of harmonic restraint relay	28
Figure 2.6	Block diagram of RADSB transformer differential relay	31
Figure 2.7	Block schematic diagram for RALDA system	34
Figure 2.8	Block diagram of numerical relay	36
Figure 2.9	Remote Terminal Unit with serial link	38
Figure 2.10	Characteristic of a mho enclosing the possible fault impedances	39
Figure 2.11	Operating characteristic of differential current relay	45
Figure 3.1	Block diagram of RADSB transformer differential relay	52
Figure 3.2	Block diagrams of DPR with the simple power system	53
Figure 3.3	Reason for delta connected CT's on wye windings	57
Figure 3.4	Complete phasing check	58
Figure 3.5	A simple power system configuration	61
Figure 3.6a	The current in the high voltage side is 30 degree leading than the current in the low voltage side	63
Figure 3.6b	The voltage in the high voltage side is 30 degree lagging than the voltage in the low voltage side	63
Figure 3.7	Voltage drop rule useful in checking or connecting wye-delta transformer bank	64





Figure 3.8	Equivalent circuit for delta-wye transformer	69
Figure 3.9	An accurate current transformers connected the 33kV-side and 11kV-side of delta-wye transformer	70
Figure 3.10	Phasor diagram of currents in current transformers	71
Figure 3.11	Current transformers applied in the power system	72
Figure 3.12	Current flowing through restraining windings and operating winding	85
Figure 3.13	Determination an impedance for the restraining windings and operating winding	86
Figure 3.14	Polarity-marked of the transformer	88
Figure 3.15	Polarity-marked of the transformer in SABER	88
Figure 3.16	Amplitude comparator characteristic	92
Figure 3.17	Phase comparator characteristic	94
Figure 3.18	One package of solid-state digital-type DPR	96
Figure 3.19	Circuit breaker tripping circuit	97
Figure 3.20	Equivalent circuit for circuit breaker	99
Figure 3.21	Current and voltage characteristics during interruption of an inductive circuit	102
Figure 3.22	Equivalent circuit for determining the required arc commutation time between main and arcing contacts	104
Figure 4.1	Simulation results of input voltage on the primary side, $\Delta$ connection of the transformer	110
Figure 4.2	Simulation results of output voltage on the secondary side, Y connection of the transformer	111
Figure 4.3	Simulation results of line current supplied from 33kV Generator	111
Figure 4.4	Simulation results obtained from current transformers connected to the $\Delta$ -side of power transformer. These results are not accurate	112
Figure 4.5	Simulation results obtained from current transformers connected to the Y- side of power transformer. These results are not accurate	112

Figure 4.6	Simulation results obtained from current transformers connected to the $\Delta$ -side of power transformer. These results are accurate	113
Figure 4.7	Simulation results obtained from current transformers connected to the Y-side of power transformer. These results are accurate	113
Figure 4.8	Simulation results obtained from 11kV-side of restraining winding	114
Figure 4.9	Simulation results obtained from 33kV-side of restraining winding	114
Figure 4.10	Simulation results obtained from operating winding	115
Figure 4.11	Simulation result of harmonic current obtained from the ground-side of delta-wye transformer	115
Figure 4.12	Circuit of 1 package digital-type DPR	116
Figure 4.13	Simulation results obtained from operating winding when internal fault or short-circuit occurred	116
Figure 4.14	Simulation results obtained from the positive-side of 1-package digital-type DPR (Figure 4.12) when internal fault occurred	117
Figure 4.15	Simulation results obtained from the negative-side of 1-package digital-type DPR (Figure 4.12) when internal fault occurred	117
Figure 4.16	Simulation results obtained from probes 11, 12, 13, 14, 15 and 16, of 1-package digital-type DPR (Figure 4.12) when internal fault occurred	118
Figure 4.17	Circuit breakers tripping circuit with the equivalent L-R circuit breaker	118
Figure 4.18	Simulation results obtained from the input of CBs tripping circuit (Figure 4.17) when internal fault occurred	119
Figure 4.19	Simulation results showing that the buffer (Figure 4.17) is used to change the 'X' or 'Don't Know' condition either to '1' or '0'	119
Figure 4.20	Simulation results obtained from an optoisolator output (Figure 4.17) when internal fault occurred	120

Figure 4.21	Simulation results showing that the comparator produce 110V output when both the inputs are 10V dc and 20V pulses as in Figure 4.17	120
Figure 4.22	Simulation results obtained from circuit breaker (Figure 4.17) that comprises of inductance and resistor	121
Figure 4.23	Simulation results showing that a very high surges occurred on the 33kV-side during circuit breakers switching	121
Figure 4.24	Simulation results showing that a very high surges occurred on 11kV-side during circuit breakers switching	122
Figure 4.25	Simulation results showing that surges occurred on the 33kV-side are still above the maximum allowable value. This is because the initial values of circuit breakers are inaccurate	122
Figure 4.26	Simulation results showing that surges occurred on the 11kV-side are still above the maximum allowable value. This is because the initial values of circuit breakers are inaccurate	123
Figure 4.27	Simulation results showing that an allowable surges during circuit breakers switching on the 33kV-side	123
Figure 4.28	Simulation results showing that an allowable surges during circuit breakers switching on the 11kV-side	124
Figure 4.29	Simulation results obtained from outputs of the 3 packages digital-type DPR when there is no internal fault occurred	124
Figure 4.30	Simulation results obtained from probes 17, 18, 19 and 20 of the buffer circuit (Figure 4.17) when there is no internal fault occurred	125
Figure 4.31	Simulation results obtained from probes 21, 22 and 23 of the comparator circuit (Figure 4.17) when there is no internal fault occurred	125
Figure 6.1	SABER Sketch window	138
Figure 6.2	Open Design window	139
Figure 6.3	Selected circuit on SABER Sketch window	139
Figure 6.4	Part Gallery window	140

Figure 6.5	Symbol Properties window	141
Figure 6.6	Basic window of Transient Analysis	141
Figure 6.7	Input/Output window of Transient Analysis	142
Figure 6.8	SABER Guide Transcript window	143
Figure 6.9	View Plot File	143
Figure 6.10	SABER Scope window with the name list of all the components	144
Figure 6.11	Result obtained from the selected component	145

## LIST OF TABLES

TABLE		PAGE
Table 3.1	Recommendation Mismatch (M) Limitation	57

# CHAPTER 1

## INTRODUCTION

Automated substations are becoming increasingly important subject for the power utilities as well as for the electricity generation and distribution. With the increasing load density of networks, it is becoming more important to consider more elaborate designs with local automation and recording of information. The main goal for these customers is uninterrupted, high quality and cost-optimised power supply, by obtaining a better performance and to improve the reliability of supplies to customers, by faster clearance of faults and restoration of supplies. The substation automation concept is based on a distributed system for automated protection, control and monitoring of power transmission and distribution substations.

The capital investment for generation, transmission and distribution of electrical power is so great that the proper precautions must be taken to ensure that the equipment not only operates as nearly as possible to peak efficiency, but also it is protected from accidents [1]. The normal path is from the power source through conductors in generators, transformers and transmission lines to the load and it is confined to this path by insulation. The insulation however may be broken down, either by the effect of the temperature and age or by a physical accident, so that the current then flows an abnormal path generally known as short circuit or fault. Whenever this occurs the destructive capabilities of the enormous energy of the power system may cause expensive damage to the equipment, severe drop in voltage loss of revenue due to interruption of service.

The purpose of protective relays and relaying system is to operate the correct circuit breakers so as to disconnect the faulty equipment from the system as quickly as possible thus minimizing the trouble and the damage caused by the faults when they do occur. With all other equipment it is only possible to mitigate the effects of short circuit by disconnecting the equipment as quickly as possible, so that the destructive effects of the energy into the faults may be minimized. Hence it is obvious that reliability, speed and selectivity are the most desired qualities of a protective relays. There are many types of relay used for power transformer protection such as electromechanical, solid-state (analogue and digital) and numerical.

Electromechanical relays that are commonly used in protection are attracted armature, moving coil, induction and motor operated. Attracted armature relays are the simplest class and the most extensively used [2]. It operates by the movement of a piece of iron into the field produced by a coil. Moving coil relays are based on the 'motor' action of a current carrying conductor in a magnetic field produces a moving coil instrument and relays. The moving coil instruments is a rotary movement comprising a short coil pivoted on an axis in its plane so that it is free to rotate between the poles of a permanent magnet. Induction relays are based on shifting by field effect. Induction relay comprises an electromagnet system that operates on a movable conductor usually in the form of a metal disc. Torque is produced by the interaction of two alternating magnetic fields which are mutually displace both in space and phase. In the induction relay, the upper and lower electromagnets can be energised by separate quantities and produce corresponding fluxes.

which satisfy the spatial displacement requirements and produce torque on the disc

Motor-operated relays are a miniature motor that can be used to perform relaying function. The operations of motor-operated relays are equivalent to the instance of induction relays operation.

Solid-state relays comprise of two components, analogue and digital. Solid-state relays give several potential advantages, among which are,

- a) due to the amplification of energising signals obtainable, the sources need only provide low power. Therefore the size of the associated current and voltage transformers could be reduced,
- b) the accuracy and hence selectivity could be improved,
- c) the fast response of the circuits could give fast tripping and clearance of faults,
- d) the flexibility of circuitry would allow new and improved characteristics, and
- e) the relays would be unaffected by the number of operations.

Solid-state relays conventionally based on the operation principles of level detector, polarity detector and phase comparator. Solid-state relays require lower burdens than electromagnetic relays but need to have less accurate characteristics because of feedback between the inputs. This limitation can easily be overcome by amplifying the output of the comparator.

Electromechanical and solid-state (static) relays have been almost completely phased out because numerical relays are now preferred by the users due to their distinctive



advantages [3]. The use of microprocessor-based relay or numerical relays, which can measure a number of input signals to derive the required operating sequence fault condition, as well as having in-built self-checking facilities, has resulted in sophisticated protection and fault-clearing schemes being developed. Increasing use of microprocessor logic-controlled sectionalisers is removing the dependence on utility control staff intervention, leading to more rapid isolation of faults and restoration of supplies [4]. Using suitable computer hardware and programs, network configuration can be automatically re-arranged on the occurrence of faults to minimise the consequences of further system outages. The microprocessor components integrated with RAM and ROM devices, and software programs make up basic unit in microprocessors relay design. Smart microprocessors are now available for control and protection. They are intelligent and surpass the performance of their conventional predecessors by far, and are at the same time highly available due to inherent self-monitoring capabilities. The evolutionary growth in the use and application of microprocessors in the substations has brought the industry to the point of considering integrated substation protection, control and monitoring system, or SCADA (Supervisory Control and Data Acquisition) [5]. Hence substation automation compromise a prototype of an intelligent controller which is equipped with many facilities to perform monitoring and control functions in substation [6]. They can communicate with each other and with higher control levels (SCADA) and provide valuable data for more effective and secure system operation.

It would be ideal if protection could anticipate and prevent faults but this is obviously impossible except where the original cause of a fault creates some effect which can